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14. ABSTRACT
This report describes ongoing work in technology transfer using UCLA-developed technology for monitoring attention and technology from PDT for automated mental state estimation.

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Report Title

Advanced Physiological Estimation of Cognitive Status - Part II

ABSTRACT

This report describes ongoing work in technology transfer using UCLA-developed technology for monitoring attention and technology from PDT for automated mental state estimation.

Advanced Physiological Estimation of Cognitive Status

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Presentation to ARL
24 May 2011

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Outline

- Technology Transfer Opportunity
  - UCLA-developed Technology (from NOIT project)
  - Technology from PDT
  - New Technology to be Prototyped in this Project
- Approach
- Design Options and Trade-offs
- Plan for Implementation
- Testing Plan
- Final Delivery and Demonstration

Technology Transfer Opportunity

UCLA-developed Technology (from NOIT project)

- Methods to control the activation of lateralized attention networks in the brain
- Methods to select task components for which right- or left-hemisphere attention networks dominate cognitive processing
- Methods to make selection of lateralized attention networks contingent on physiological estimation of cognitive status (e.g. fatigue, overload)

Technology Transfer Opportunity

Technology from PDT

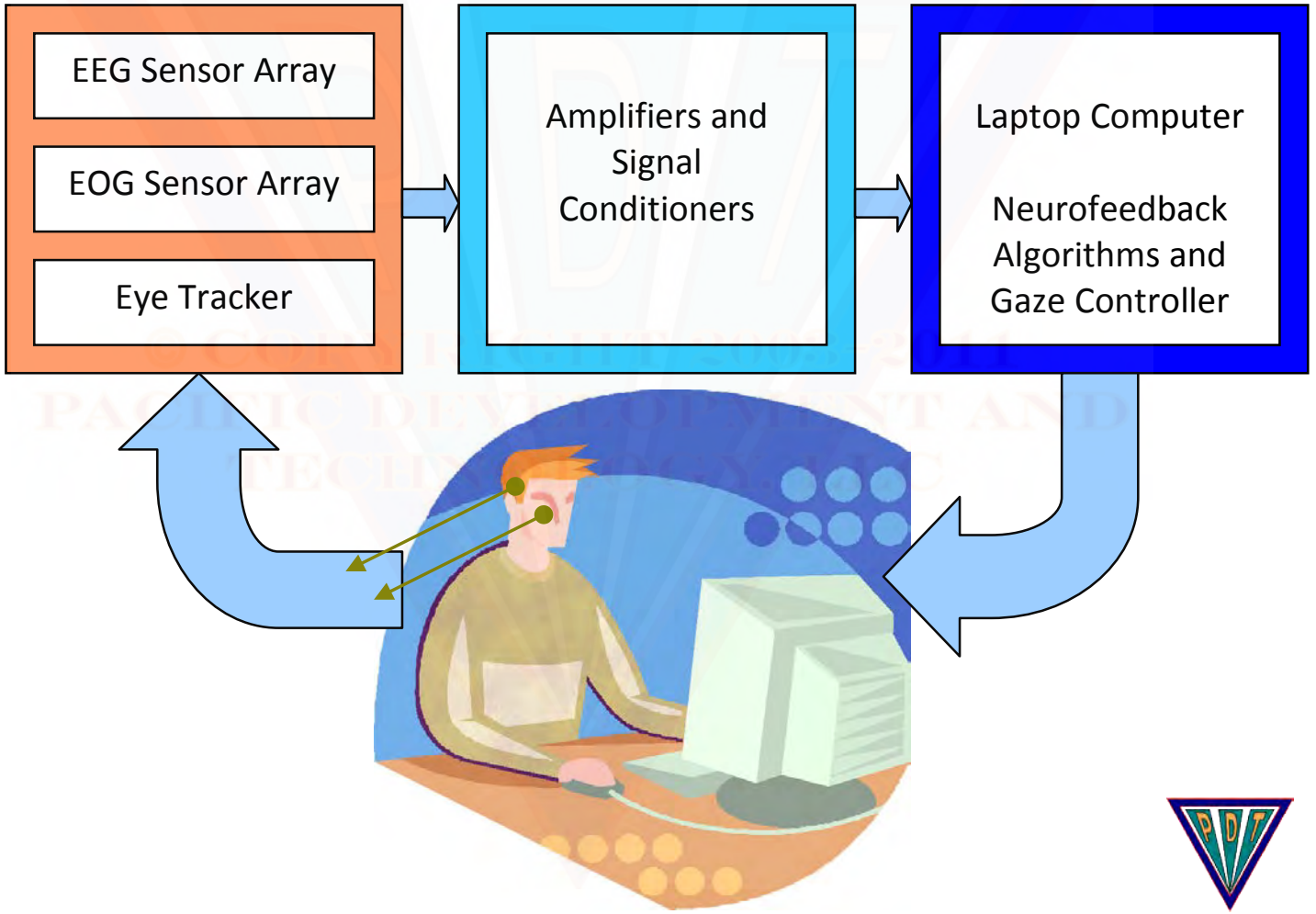
- Methods to acquire various physiological signals (EEG, EOG, EMG, ECG, etc.)
- Methods to process physiological signals (artifact control, feature extraction)
- Methods to combine and decorrelate different multimodal signals
- Algorithms to estimate fatigue, inattention, and to detect cognitive overload

Technology Transfer Opportunity

System to be Integrated and Prototyped for ARL

- Integrated hardware for visual display task experiments and biosignal recording
- Real-time control of displays contingent on gaze
- Real-time control of displays and tasks contingent on cognitive status
- Demo paradigms and software tools implemented in the system with user manual

Integrated Hardware for Experiments



EEG Sensor System

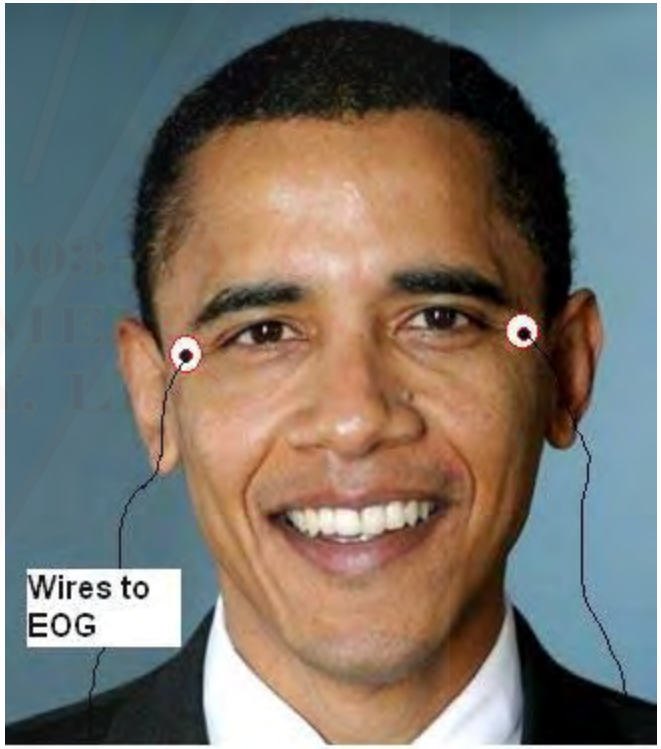
g.*USBamp* *, **

- internal 24-bit ADC and digital signal processor
- 16 channels (expandable, stackable)
- USB interface
- DC-coupled
- Rugged, depdendable
- Proven in BCI applicartions
- Compatible with system software (BCI2000, APECS)

EOG Sensors

Integrated with the USB Amp

- Delegate one block of (4) channels for EOG
- Use disposable, pre-gelled, self adhesive electrode strips (no prep; no cleanup)



Eye Tracker Design Options

- SMI RED500
  - Good sampling rate (500 hz)
  - Integrated with flat panel display
  - Lower cost than other options
  - Unknown integration factors

SMI
SensoMotoric Instruments

- EyeLink 1000 Desktop System
  - Highest sampling rate (1,000/s)
  - Cameras are separate from the display
  - High cost
  - Unknown integration factors

SR Research
EyeLink

- Tobii X60/120/300
  - Adequate sampling rate (300/s)
  - Integrated into flat panel display
  - Proven integration with BCI hardware & software
  - High cost

tobii
www.tobii.com

Eye Tracker Performance

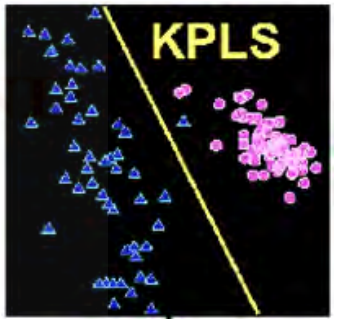
Feature	SMI RED500	SR EyeLink 1000	Tobii X60/120/300
Temp. resolution	500 Hz binocular	1000 Hz monoc.	300 Hz binocular
Spatial resolution	0.03º	0.01º	0.08º binocular
Gaze position acc.	<0.4º (typical)	0.25º to 0.5º (typ.)	0.4º to 0.6º
Processing delay	<0.5 ms (typ.)	1.8 ± 0.6 ms	1.0 to 3.3 ms
Head velocity max	50 cm/s	Not allowed	50 cm/s
Blink recovery	4 ms (max.)	1.0 ms	Not stated
Tracking recovery	90 ms	Not stated	10 to 165 ms
Gaze track range	40º V x 60º H	40º V x 60º H	35º
API/SDK	Free	Free	Free
Data interface	Ethernet	Ethernet	Ethernet

System Capabilities and Functions

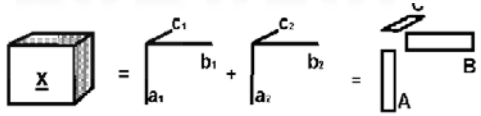
- Control of Visual Stimuli
  - Report the gaze with 0.5 deg accuracy
  - Report the gaze with < 10 ms latency
  - Select the exact position of next stimulus in visual field
  - Abort stimulus when eye is moving or lost tracking
  - Increased gaze control accuracy with PDT EOG timing
- Contingent Display
  - Only display information to the desired hemifield
  - Only display information appropriate or optimal for task
  - Only display information optimal for cognitive state

Software Capabilities: BCI2000 Software and PDT APECS Plugins

- Programmable implementation of experiments in attention
- Recording and processing of biosignals
- Synchronization of biosignals, gaze and task stimuli
- Real-time estimation of cognitive states: fatigue, inattention, overload
- EEG biofeedback of spectral, coherence, KPLS, or PARAFAC features
- Estimation of PLS and PARAFAC models (with optional Matlab licenses)



PARAFAC



Assembly, test, & delivery

- System will be assembled by PDT and consultants
  - Acquisition of components
  - Physical assembly
  - Software installation
- Preliminary testing will be done at UCLA by PDT staff and consultants
  - Test and validate; compare with UCLA system
  - Perform adjustments and fine-tuning
- Delivery to ARL in Q2 2012
  - Physical delivery and setup by PDT
  - On-site testing, verification, and demonstration
  - On-site user training (one day)

Summary

The proposed ARL system will allow for:

- Advanced experiments in attention, fatigue, cognitive overload, and control of hemispheric resources
- Experimental task contingencies for EEG based estimation of cognitive states and real-time gaze
- Experiments on using EEG biofeedback to enhance operator performance and mitigate fatigue or overload